Get 20% more hydrogen than nameplate in your next turnaround

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Johnson Matthey (JM) **CATACEL SSR™** steam reforming catalyst technology enables a low capital solution within a normal turnaround to meet increased hydroprocessing demand within the operating constraints of onsite hydrogen production.

The International Maritime Organization (IMO) low sulfur marine fuel regulation is in place for 2020. There are still technology decisions being made and some wait and see approaches as to how the regulation will be managed.

It is understood that a predominate portion of the low sulfur fuel required for meeting this regulation will be from increased low sulfur diesel production. Some complex refineries have the capacity to meet these increased hydro processing needs as sweeter tight oils have replaced sour crudes. This increased diesel production will require more hydrogen production from the site. Processing the tight oils has increased production of catalytic reformers resulting in more hydrogen contribution to the site than in previous years. With this additional source of hydrogen on site, many hydrogen plants are running at 70-80% utilization. The IMO low sulfur marine fuel regulation, as well as refiners hydro processing more bio-based feeds that are lean on hydrogen, are creating a step change in hydrogen demand. Even with the increase in hydrogen availability from the catalytic reformer, many refiners are needing about 20% more hydrogen than nameplate within their refineries.

Traditionally the onsite choices that a refiner has for a 20% uprate are either building a grass roots hydrogen plant or uprate an existing hydrogen plant by adding a heat exchange reformer. These solutions tend to pose challenges for the refiner in the following ways:

- Availability of capital
- Plot plan
- Turnaround scheduling
- Compression
- Steam production
- Increased asset wear

JM's Stackable Structured Reactor – **CATACEL SSR** steam reforming catalyst technology addresses and helps minimize or remove these challenges while enabling a 20% uprate above nameplate hydrogen production. This article will address each of these challenges with respect to an SSR technology 20% uprate.

Availability of capital

Downstream margins are under tremendous pressure and compression, reducing the availability of capital. Improvements in capital utilization and efficiency need to be apparent for expansion projects to come into consideration. A **CATACEL SSR** technology uprate offers one of the lowest capital usages for increased hydrogen production thereby increasing overall return on investment - ROI. The **SSR** technology uprate does require debottlenecking of the fired reformer to enable the process flow and increased heat load to be achieved with the fired reformer. Typically, the fired section of the steam methane reformer needs to be modified for this increased heat load, particularly the burners and ID fan. Depending on the plant, additional upgrades may be needed in the feed purification system, the outlet header of the fired reformer, and the pressure swing absorption – PSA system that purifies the hydrogen product. The level of capital needed will vary dependent on the modifications required, but even with this the SSR 20% uprate still offers the lowest capital for increased production by 20-50%.

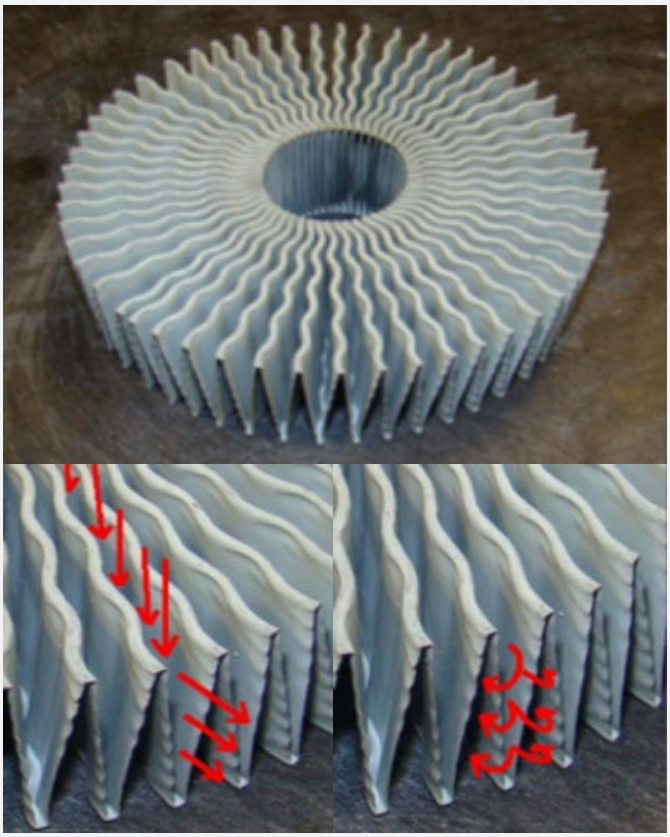
Plot plan / turnaround scheduling

As an operating company considers increased capacity, some additional plot plan needs to be considered either for a grass roots plant or adding additional equipment. Many refineries are in populated areas close to metropolitan cities allowing limited space for expansion or addition. Most hydrogen plants have even less space available near the plant itself. Beyond having the space, extensive prework needs to be accomplished to make that space ready including environmental regulations, infrastructure, and preparing the site. These activities require site access during plant operation or additional work to be accomplished within the upgrade turnaround. For complex refiners that have the hydro processing capacity available for additional diesel production, extension to the typical 3-week turnaround schedule quickly impacts the cost of the turnaround. The missed opportunity of production can quickly add 10-30% to the cost of the project. Obviously, a grass roots hydrogen plant will require substantial space and many approvals. Most grass roots hydrogen plants are taking 24-36 months from project approval to beneficial operation. This timing is close to a full hydroprocessing turnaround cycle to achieve production. Upgrades that add equipment to the plant are challenging to complete in a 3-week turnaround. Delays in the turnaround schedule can remove millions of dollars in production from being achieved. A **CATACEL SSR** technology uprate replaces the existing pelleted reformer catalyst in the same time that it would take to load pelleted catalyst. The typical modifications to the steam methane reformer, burners and ID fan, are accomplished in the 3-week turnaround.

Typical Refinery Hydrogen Plant with Minimal Plot Plan Availability

CATACEL SSR technology is a stackable structured reactor that has been designed for the reformer duty. Using catalyst coated thin metal foils, SSR technology packs 40% more surface area per unit volume than pellets utilizing the existing reformer tubes to drive the additional reaction needed for the increased flow. Fired reformer performance in a hydrogen plant relies on getting the heat into the process gas. While developments have occurred through the years on pelleted reforming catalyst, the improvements are small and still rely heavily on the randomness of pelleted catalyst loading. The unique patented design of **CATACEL SSR** technology directs the process gas to encounter all the catalyst surface available and then directs this flow against the inside tube wall to maximize heat transfer and process gas reheat while moving to the next layer of surface area in the structure. This results in a 20-30% increase in heat transfer into the process gas. The **CATACEL SSR** technology reactor reaction and heat transfer intensification enables a tight steam methane approach to equilibrium to be maintained with the 20% up-rate achievement using the existing reformer geometry.

DSSR – Stackable Structured Reactor



Directed Flow Pattern Across Coated Foil Section of SSR reactor

Compression

Many hydrogen plants are limited on feed gas compression. The increased 20% uprated flowrate can put too much resistance to flow on the feed gas compression for a pellet loaded reformer making the uprate not achievable. In a similar way, adding a heat exchange reformer adds additional resistance to flow and added pressure drop through the added piping and heat exchange reformer equipment. The unique patented design and flow pattern can reduce the reformer pressure drop by 20%. The steam methane reformer pressure drop can be as much as 60 -70% of the flow sheet pressure drop. A **CATACEL SSR** technology 20% uprate adds no additional pressure drop to the steam methane reformer, minimizing the resistance to flow on the feed gas compressor.

Steam production

Most hydrogen plants produce more steam through the heat recovery system of the hydrogen plant flowsheet than can be used in the hydrogen plant, making it a net steam exporter. The steam is used within the overall steam system of the refinery for hydroprocessing units and for driving some of the major refinery equipment. While several refiners are moving from steam driven to electrically driven equipment, many still rely on and value the steam export from the hydrogen plant for the rest of the refinery. Adding a heat exchange reformer depends on the fired steam methane reformer to produce the process steam reducing or eliminating the steam export from the hydrogen plant. With a SSR technology 20% uprate, additional export steam can be produced for the refinery. Additionally, if there are limits on the hydrogen plant process gas boiler / steam raising system, the **SSR** technology is able to operate at lower steam to carbon ratios as it is more reactive changing the conditions throughout a natural gas fed fired reformer to avoid carbon formation.

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Increased asset wear

When uprating an existing plant, operators are concerned that the uprated condition will create greater wear on the asset adding to the cost of operation over the plant lifecycle as well as increasing potential for mechanical failures within the flow sheet. Replacing the steam methane reformer tubes tends to be one of the higher cost asset replacements in the hydrogen plant. Most of the major equipment is designed for the lifecycle of the plant but the reformer tubes are usually expected to be changed one to two times in the plant's lifecycle. With most hydrogen plant uprates, the additional firing and reforming heat load required can result in higher reformer tube wall temperatures reducing the life of the tubes exponentially. **CATACEL SSR** technology is highly effective in extracting heat from the inside reformer tube wall. This step change in heat transfer effectiveness is resulting in hydrogen plants utilizing SSR technology to experience a 20 degrees Celsius reduction in reformer tube wall temperatures. For the SSR technology 20% uprate, there is no increase in reformer tube wall temperatures from those experienced at nameplate production. In other words, the **SSR** technology 20% uprate adds no increased asset wear on the steam methane reformer tubes and minimizes the risk of reformer tube failures thus improving the safety of the operation even with the uprate.

Common Asset Wear Mechanism of Overheated SMR Tubes Leading to Reformer Tube Failures

CATACEL SSR technology continues to grow its experience profile demonstrating its capabilities while minimizing the risk of its use for hydrogen applications. SSR technology has been designed and operating successfully in over a dozen steam methane reformer applications, it has been loaded in over 650 reformer tubes, established two lifecycles of performance, and designed into 5 uprating applications. JM is not only investing in optimizing this technology but with the growing demand of this product it is doubling the manufacturing capacity by 2021.

Summary

With changing regulations on IMO marine fuel standards, refiners are reviewing their hydrogen management needs and realize more is needed for the increased hydroprocessing demands including bio feed processing. An SSR technology 20% uprate enables a timely increase in hydrogen plant production to be achieved within a typical turnaround. It provides a low capital and high ROI solution without impacting barriers to hydrogen plant increases like feed gas compression, steam export, and steam methane reformer tube wear. It also minimizes the time to beneficial operation compared to other solutions like a grass roots plant or addition of a heat exchange reformer. The **SSR** technology 20% uprate requires less plant modifications therefore reducing the risk and increasing safety to the refiner in achieving these additional hydrogen needs.

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